Opportunities and considerations for power plant refurbishment and upgrades

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Eskom’s generation resources

- One of the top 10 utilities in the world by generation capacity
- Eskom Generates +- 95% of electricity used in SA and more than 40% used in Africa

In South Africa

In Africa

95%

45%
Generation plant mix

- **23** operating power stations & **4** non-dispatchable mini hydro plants. Of these, there are **13** coal fired power stations
- Eskom net capacity ~ **41.9 GW**
What can refurbishment & upgrades provide?

- **Prudent Asset Management** with Sustained Reliability
- **Improved Performance** (both environmental and plant)
- **Improved Reliability**
- **Life Extension**
- **Increase** in Power Output

- The above is available at *marginal cost* compared to new capacity.
Prudent Asset Management Objective:
To maintain plant availability and reliability within targets, while controlling costs, utilising a suitable balance between plant repair, refurbishment and replacement.

The installed plant of Generation is mature with an average age of almost 30 years. Some plants have already reached 300% of their design life, which will require substantial investment to ensure suitable availability.
Plant Age and Wear Considerations

• Critical to quantify the effects of ageing
• Important to estimate the remaining life of plant components
• Affects the cost of the refurbishment, life extension program and the phasing of interventions.
• Major mechanisms include:
  • Creep,
  • Fatigue,
  • Erosion and
  • Corrosion.
• Note: Equipment designs include allowances for wear - safety factors intended for a specific finite period. Any decision to operate the plant beyond this design life requires a careful assessment into the means of overcoming the ageing process.
The coal fired fleet has units of differing age, the age of the plants is given below (based on the average age of the units at a station):

<table>
<thead>
<tr>
<th>STATION</th>
<th>AGE: 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARNOT</td>
<td>40</td>
</tr>
<tr>
<td>CAMDEN</td>
<td>35</td>
</tr>
<tr>
<td>DUVHA</td>
<td>31</td>
</tr>
<tr>
<td>GROOTVLEI</td>
<td>30</td>
</tr>
<tr>
<td>HENDRINA</td>
<td>42</td>
</tr>
<tr>
<td>KENDAL</td>
<td>23</td>
</tr>
<tr>
<td>KOMATI</td>
<td>35</td>
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<tr>
<td>KRIEL</td>
<td>36</td>
</tr>
<tr>
<td>LETHABO</td>
<td>26</td>
</tr>
<tr>
<td>MAJUBA</td>
<td>16</td>
</tr>
<tr>
<td>MATIMBA</td>
<td>24</td>
</tr>
<tr>
<td>MATLA</td>
<td>32</td>
</tr>
<tr>
<td>TUTUKA</td>
<td>26</td>
</tr>
</tbody>
</table>

The average age of the fleet is currently 30 years
Refurbishment Cost Considerations
Based on average expenditures in the fleet the average “prudent” maintenance cost per site has been derived.

Based on average expenditures in the fleet the average “prudent” capital cost per site has been derived.

Last 10 yrs:
- reduced investment
- reduced availability.
(10 – 20%)
Fleet Expenditure: Refurbishment and Upgrades

Breakdown of Refurbishment & Upgrade Projects in Long Term Plans:
The details given here represent the best estimates of future refurbishment in Eskom.
Correlation of Refurbishment & Upgrades to Unplanned Unavailability

Life Cycle Cost
- Turbine: 19%
- Other: 7%
- Mills: 2%
- Cond. Tubes: 3%
- Motors: 4%
- Heaters: 4%
- Sw/gear: 5%
- Transformers: 6%
- Ash: 7%
- C & I: 14%
- Generator: 12%
- Draught Plant: 7%
- Boiler: 10%

Driven mainly by redundancy

Balance under routine maintenance

UCLF
- Turbine: 32%
- Other: 2%
- Mills: 7%
- Condensor: 4%
- HP/ LP feedheaters: 5%
- Switchgear: 0%
- Transformers: 3%
- Ash Dump: 5%
- Draught Plant: 12%
- Generator: 7%
- Boiler: 22%
Life Cycle Costs: Overall Station Costs (example Hendrina)

Total Maintenance & Refurb costs average out at 1.3% of capital cost per year. In line with industry norms.

Cost over the life of asset

- Maintenance Cost over the 60 year life $\frac{1}{2}$ of initial capital cost to build.
- Major Refurbishment over 60 year life only $\frac{1}{3}$ of initial capital cost to build.

Important to optimise this element because it compensates for all other factors!
The above graph shows the average cost profile of the fleet as the red curve, while the component replacement strategy costs are shown in the multi coloured layers.
Refurbishment Strategies
Boiler Considerations

- Some components last the life of the plant, but many will not.
- Essential to determine the optimal stage for replacement.
- Main steam pipework complete replacements at some plants and on some units. (>higher reliability and lower overall life cycle costs)
- Economisers, total replacement is often essential, improve efficiencies where appropriate.

In assessing plant condition the following major areas receive detailed attention:

- HP Pipework integrity
- Boiler erosion, fatigue etc.
- Header life assessments

**Boiler Refurbishment Strategy**

- Replace sections or complete main steam pipework
- Replace economisers, superheaters, evaporator tubes either as sections or individual tubes
- Replace headers as required.
Turbine Considerations

- Turbine rotor is the one component subjected to the most stress due to thermal transients generated during start up, shutdown and cyclical operation.

- Upgrades consider like for like or efficiency improvements.

- In assessing the plant condition in the turbine the following areas are of major significance and receive detailed attention:
  - Rotor
  - Casing
  - Nozzle
  - Control system

- **Turbine Refurbishment Strategy**
  - Replace HP, IP & LP blades
  - Replace select casings
  - Replace select rotors
  - Replace control systems
• Subjected to enormous internal stresses - interaction of the huge electromagnetic fields and the structure of the generator.

• Ageing not dominantly a result of operational cycles but often affected by internal high frequency cycles. The effect of operational cycles also has an effect, mainly on the rotors.

In assessing the plant condition of the generator the following areas are of major significance and receive detailed attention:

• Stator
• Rotor windings and excitation systems
• Rotor forging

• **Generator Refurbishment Strategies**
  • Rewind many stators
  • Rewind most rotors
  • Replace select exciters
AGEING OF PROCESS CONTROL EQUIPMENT MOSTLY A FUNCTION OF TECHNOLOGICAL REDUNDANCY

• Differs somewhat from other plant systems – modernisation may update the control philosophy including operator interfaces etc.

• Replacement strategy of approximately 5 years on the human interface and 15 years on central control equipment.

• Degradation of process control equipment is usually not the major consideration.

• Support and spares availability of current designs the problem.

• Original equipment choice gave an extended life but modern replacements will give rise to shorter replacement cycles.

• Currently replacing at Kriel, Matla, Duvha and turbine control at Matimba. Other stations to follow.
MANY ELECTRICAL COMPONENTS HAVE 1 OR 2 REPLACEMENT CYCLES OVER THE 50 – 60 YR LIFE

Replacement still based on condition, indicative lives shown here.

**Replacement cycles:**
- MV & LV cables – 30 years
- Lifts – 25 years
- MV motors – 30 years
- Metering – 12 years
- CT’s and VT’s – 20 years
- Switchgear – 60 years (depends on safety specs)
- DC Motors - never
Upgrades
Environmental Upgrades

As presented earlier 36% of Refurbishment & Upgrade Expenditure allocated to Air Quality:

- Particulate reduction
- NOx reduction
- SOx reduction
Examples of upgrades currently under development

Augmentation of dry cooling at Matimba (5% improvement)

• Potential to compensate for adverse conditions causing load losses
• Could increase number of current cooling banks
• Could build stand alone cooling tower

Capacity increase at Hendrina (up to 7 MW per unit)

• Most of the impact would be efficiency improvement
• Replace HP turbines with high efficiency turbines
• Could increase capacity by 7MW per unit
• Alternatively optimise boiler performance and unit availability
Examples of upgrades currently under development or being implemented

Rail and Road Infrastructure for coal supply

- Majuba, Tutuka
- Reduce road transport
- Improved safety
- Lower cost

Upgrades to coal stockyard and ash dump drainage systems

- Improved drainage in some cases
- Lining of dumps where necessary
- Some are new installations entirely (Kriel, Camden)
Refurbishment & Upgrade Cost Impacts

- Refurbishment & Upgrade costs split across many competing priorities such as:
  1. Environment
  2. Sustaining current performance while extending life to 60 years
  3. Improving on current performance
  4. Capacity increase.
• The VGB identified that the Upgrade Potential of the ESKOM Fleet is:

1. Significant
2. Costs could be 30% of new build
3. Life extension of potentially 15 years more
4. Improved Reliability with forced outages reduced by ~ 3%
5. Increase of Efficiency ~ 2 % net
Capacity Upgrades and Life Extension leading to maximum carbon flexibility

Capacity = Existing Plant + New build + Capacity Upgrades

Replace new capacity with upgrades > maximum flexibility in uncertain carbon future!

Demand Supply

Capacity Upgrade

Demand
New build

Existing plants

time
Eskom …ensuring Reliable Capacity for South Africa through Prudent Asset Management!

A Process involving:

- Sustainable plant
- Environmentally compliant plant
- Reliable plant
- Long term availability
- Upgraded performance
Thank You!